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COMPLETED

FLOOD INSURANCE STUDY

ORIGINAL

CITY OF MOORHEAD, MINNESOTA

CLAY COUNTY

MAY 4, 1987

Federal Emergency Management Agency

COMMUNITY NUMBER - 275244

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TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
1.1	Purpose of Study	1
1.2	Authority and Acknowledgments	1
1.3	Coordination	1
2.0	AREA STUDIED	2
2.1	Scope of Study	2
2.2	Community Description	2
2.3	Principal Flood Problems	2
2.4	Flood Protection Measures	4
3.0	ENGINEERING METHODS	5
3.1	Hydrologic Analyses	5
3.2	Hydraulic Analyses	6
4.0	FLOODPLAIN MANAGEMENT APPLICATIONS	7
4.1	Floodplain Boundaries	7
4.2	Floodways	8
5.0	INSURANCE APPLICATION	10
6.0	FLOOD INSURANCE RATE MAP	10
7.0	OTHER STUDIES	11
8.0	LOCATION OF DATA	11
9.0	REFERENCES AND BIBLIOGRAPHY	11

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TABLE OF CONTENTS (continued)

Page

FIGURES

Figure 1 - Vicinity Map 3

Figure 2 - Floodway Schematic 10

TABLES

Table 1 - Historic Discharges 4

Table 2 - Summary of Discharges 6

Table 3 - Floodway Data 9

EXHIBITS

Flood Profiles

Red River of the North Panel 01P

Flood Insurance Rate Map Index
Flood Insurance Rate Map

Elevation Reference Marks

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FLOOD INSURANCE STUDY

CITY OF MOORHEAD,
CLAY COUNTY,
MINNESOTA

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study revises and updates a previous Flood Insurance Study for the City of Moorhead, Clay County, Minnesota. This information will be used by the community to update existing floodplain regulations as part of the regular phase of the National Flood Insurance Program. The information will also be used by local and regional planners to further promote sound land use and floodplain development.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the state (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by the U.S. Army Corps of Engineers (COE), St. Paul District (the Study Contractor) for the Federal Emergency Management Agency (FEMA), under Inter-Agency Agreement No. EMW-E-1153, Project Order No. 15. This study was completed in August 1985.

1.3 Coordination

The potential Flood Insurance Study was discussed in detail and study limits were defined at a meeting held on June 14, 1983, in the city offices. Also discussed during the meeting were the hydrologic analyses and potential floodway alignments. Attending the meeting were representatives of the City of Moorhead, FEMA, the States of Minnesota and North Dakota, and the Study Contractor.

At subsequent meetings held on September 18 and 19, 1984, in the city offices, the potential floodway alignment and its impact on the city were discussed in detail. Attending the meetings were representatives of the Cities of Moorhead, Minnesota, and Fargo, North Dakota, the States of Minnesota and North Dakota, the general public, and the Study Contractor. A floodway alignment coordination meeting was held in the city offices in March 1985. Attending the meeting were representatives of the City of Moorhead, the Minnesota Department of Natural Resources (MDNR), and the Study Contractor.

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2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the City of Moorhead, Clay County, Minnesota. The area of study is shown on the Vicinity Map (Figure 1).

Flooding caused by overflow of the Red River of the North was studied in detail within the community.

The areas studied were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through August 1990. The scope and methods of study were proposed to and agreed upon by FEMA and the City of Moorhead.

2.2 Community Description

The City of Moorhead is located in extreme west-central Clay County on the western Minnesota border. Moorhead is bordered on the west by the City of Fargo, North Dakota, on the east by the City of Dilworth and the unincorporated areas of Clay County, and on the north and south by the unincorporated areas of Clay County. The Red River of the North divides the twin Cities of Moorhead, Minnesota, and Fargo, North Dakota. The area is served by Interstate 94 and U.S. Highways 10 and 75. According to the 1980 census, the population of Moorhead is 29,998 (Reference 1).

The area's increasing population directly enhances the economic growth of Moorhead. The economy is based primarily on agriculture and agricultural related industries. However, a number of retail and commercial businesses recently have integrated into the economy.

The Red River of the North meanders through the former lake bed of Lake Agassiz and forms the Minnesota-North Dakota border. The drainage area at the Fargo U.S. Geological Survey (USGS) gaging station is 6,800 square miles. The average discharge of 559 cubic feet per second (cfs) is only 8 percent of the channel capacity (Reference 2). The glacial Lake Agassiz produced the extremely flat terrain of the Moorhead area. The soil mixture of clay, silt, and sand makes for excellent farmland (Reference 3).

The climate of Moorhead is typical of the Great Plains, characterized by cold winters and warm summers. Monthly average temperatures range from 5.8 degrees Fahrenheit (^{o}F) in January to 70.7 ^{o}F in July. The mean annual temperature of the area is 41.5 ^{o}F. The City of Moorhead averages 19.62 inches of precipitation annually. Seventy-five percent of the year's rain falls between April and September (Reference 4).

2.3 Principal Flood Problems

The Red River of the North basin exhibits a number of unusual characteristics making it particularly susceptible to flooding. Because the basin is so flat, it allows water to spread out and inundate vast areas

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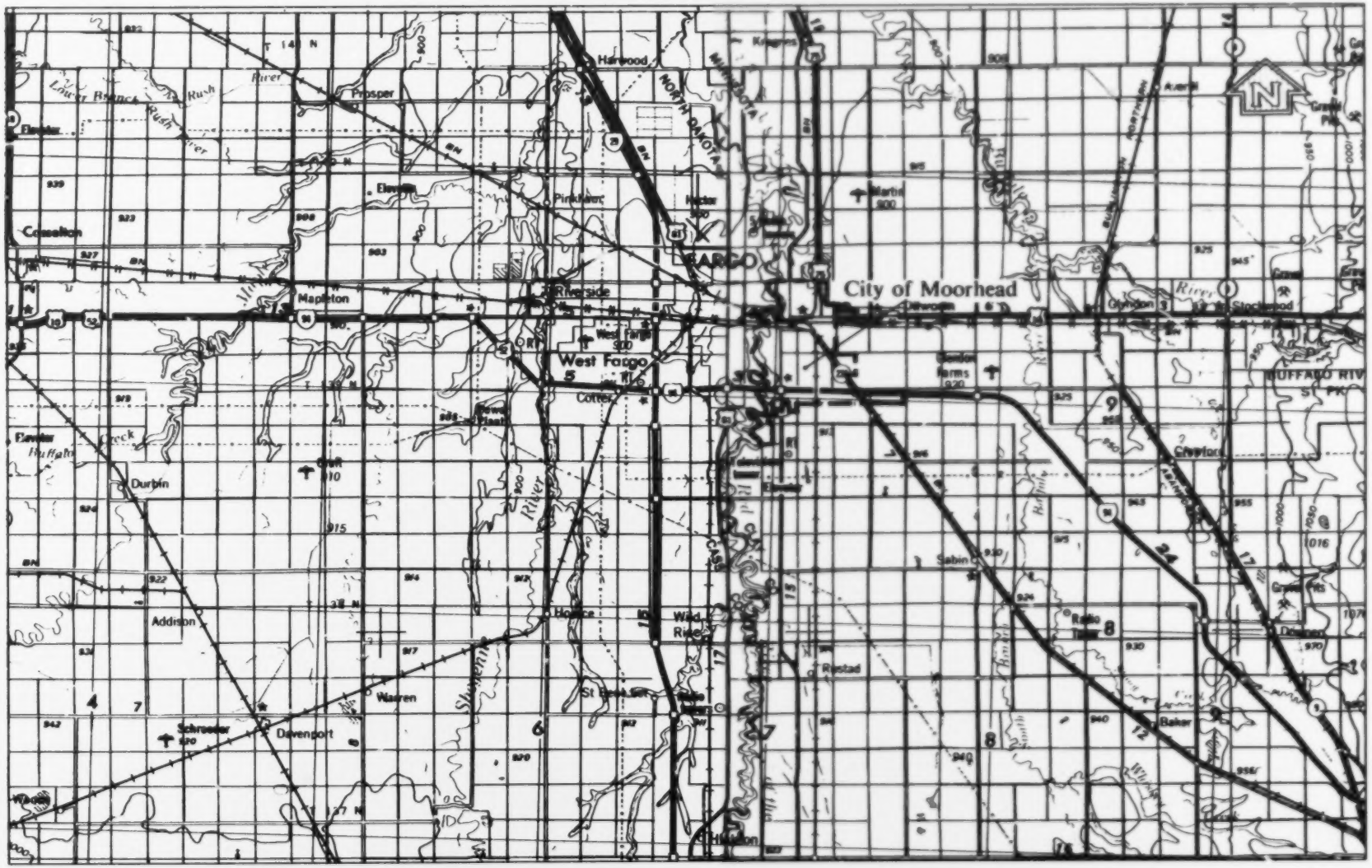

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MOORHEAD, MN

(CLAY CO.)

APPROXIMATE SCALE

4 0 4 8 12 MILES

VICINITY MAP

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adjacent to the river. The northerly direction of flow is a unique and important element in the overall flood pattern of the river. The melting season begins in the southern sections and progresses slowly northward, synchronizing the flood peak on the Red River of the North with tha flood peaks of its tributaries (Reference 5).

Damages from flooding include inundation of agricultural and residential bu.ldings and damage to roads and to agricultural land.

Numerous large floods have occurred in the Red River of the North basin since the beginning of collection of flood data. The floods of 1882, 1897, 1950, 1965, 1966, and 1969 were recorded as the largest (Reference 2). The most recent large flood occurred in 1979. The largest recorded flood occurred on April 7, 1897 (Reference 2). Table 1 presents historic flood data.

TABLE 1 - HISTORIC DISCHARGES

USGS Gaging Station [1]
Fargo, North Dakota

Date	Maximum Stage (feet)[2]	Peak Discharge (cfs)	Estimated Recurrence Interval
April 1969	37.34	25,300	70-year
April 1979	34.93	17,300	27-year
April 1978	34.41	17,500	28-year
April 1952	34.65	16,300	24-year
April 1943	34.30	16,000	24-year
April 1975	33.26	13,200	16-year
April 1965	30.50	11,400	12-year
April 1966	30.10	10,700	11-year

[1]USGS Gaging Station No. 0505400

[2]Gage zero 861.80 feet National Geodetic Vertical Datum of 1929 (NGVD)

2.4 Flood Protection Measures

Federal flood damage reduction measures in existence, which benefit the City of Moorhead, consist of the Orwell Reservoir on the Otter Tail River, a tributary to the Red River of the North, at the City of Breckenridge, Minnesota, and the Lake Traverse Reservoir at the headwaters of the Bois de Sioux River. Both reservoirs provide floodwater storage and are operated to reduce peak discharges downstream.

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The current COE Flood Damage Reduction Study conducted under the "Fargo-Moorhead Urban Water Resources Study" is investigating potential flood damage reduction measures in the immediate and surrounding Fargo-Moorhead area. The study was completed in May 1985 (Reference 6).

Levees exist in the study area that provide the community with some degree of protection against flooding. However, it has been ascertained that these levees may not protect the community from rare events such as the 100-year flood. The criteria used to evaluate protection against the 100-year flood are 1) adequate design, including freeboard, 2) structural stability, and 3) proper operation and maintenance. Levees that do not protect against the 100-year flood are not considered in the hydraulic analysis of the 100-year floodplain.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1-percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each riverine flooding source studied in detail affecting the community.

Peak discharges for the Red River of the North were developed by the COE (Reference 7) and the USGS (Reference 8) based on historical data from gaging stations at the Cities of Wahpeton and Fargo, North Dakota, and the City of Halstad, Minnesota. The COE utilized two computer programs, Flood Flow Frequency Analysis and Regional Frequency Computation, to determine the flows. These flows were compared with those obtained from Bulletin No. 17 (Reference 9). The USGS did an adjusted log-Pearson Type III flood frequency analysis. This information was used to develop a discharge-drainage area relationship for the Red River of the North. Discharges used in this Flood Insurance Study were submitted to and approved by the MDNR Inter-Agency Review Committee. The committee

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consisted of representatives from the MDNR, the USGS, the COE, and the U.S. Department of Agriculture, Soil Conservation Service (SCS).

Peak discharge-drainage area relationships for the 10-, 50-, 100-, and 500-year floods of each flooding source studied in detail in the community are shown in Table 2.

TABLE 2 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQ MILES)	PEAK DISCHARGE (CFS) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
RED RIVER OF THE NORTH at Fargo, North Dakota	6,800	10,300	22,300	29,000[1]	50,000

[1]interagency coordinated discharge

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

Cross sections used in the analyses were located at close intervals upstream and downstream of bridges and other hydraulic structures to allow computation of significant backwater effects of these structures. Other cross sections were located along the river to provide a typical representation of the river valley topography. Data for channel and overbank portions of the cross sections, bridge dimensions and elevations, and other structures were field surveyed. When necessary, the cross-section data was supplemented with data from topographic maps obtained by photogrammetric methods with aerial photographs taken April 1984 (Reference 10).

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles. For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the Flood Insurance Rate Map.

Effective flow areas of the floodplain cross sections, loss coefficients for bridges and other channel obstructions, and roughness coefficients (Manning's "n") ranged from 0.035 to 0.037 in the channel and from 0.052 to 0.087 in overbanks for the 100-year flood event. Adjustments were made to the Manning's "n" coefficients until the computed profile matched the historic high-water profile of the April 1969 flood with a tolerance of 0.3 foot. This was done using the HEC-2 step-backwater computer program (Reference 11).

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The starting water-surface elevations were obtained from an elevation discharge rating curve at river mile 436.02. The rating curve was based on a detailed backwater analysis downstream of river mile 436.02 and historic high-water profiles in the vicinity.

Water-surface elevations for floods of the selected recurrence intervals along the Red River of the North were calculated utilizing the HEC-2 computer program (Reference 11).

Flood profiles were drawn showing the computed water-surface elevations for floods of the selected recurrence intervals. In cases where the 50- and 100-year flood elevations are close together, due to limitations of the profile scale, only the 100-year profile has been shown.

The hydraulic analyses for this study are based only on the effects of unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

All elevations are referenced to the NGVD. Elevation reference marks used in this study are shown on the map and described in the exhibit labeled Elevation Reference Marks.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study provides 100-year flood elevations and delineations of the 100- and 500-year floodplain boundaries and 100-year floodway to assist communities in developing floodplain management measures.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the 100- and 500-year floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:2400 with a contour interval of 2 feet (Reference 10).

The 100- and 500-year floodplain boundaries are shown on the Flood Insurance Rate Map. On this map, the 100-year floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, AH, AO, A99, V, and VE) and the 500-year floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 100- and 500-year floodplain boundaries are close together, only the 100-year floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

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4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces the flood-carrying capacity, increases the flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 100-year floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. However, in Minnesota, floodplain encroachment on the boundary water between North Dakota and Minnesota is limited to a 0.75-foot increase in flood heights above pre-floodway conditions at any point. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodway alignment presented has been coordinated with and approved by the North Dakota State Water Commission, the MDNR, and the City of Fargo, North Dakota. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections and are shown in Table 3, Floodway Data. The computed floodways are shown on the Flood Insurance Rate Map. In cases where the floodway and the 100-year floodplain boundaries are either close together or collinear, only the floodway boundary is shown. Portions of the floodway for the Red River of the North lie outside the corporate limits.

The area between the floodway and the 100-year floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 0.25 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 2.

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC.)	REGULATORY (FEET NGVD)	WITHOUT FLOODWAY (FEET NGVD)	WITH FLOODWAY (FEET NGVD)	INCREASE (FEET)
RED RIVER OF THE NORTH								
A	446.68	1390	20,380	1.4	895.8	895.8	896.2	0.4
B	447.76	580	11,860	2.4	896.2	896.2	896.6	0.4
C	448.76	720	12,190	2.4	897.1	897.1	897.4	0.3
D	449.63	1110	14,225	2.0	897.5	897.5	897.9	0.4
E	450.49	1000	15,540	1.9	897.9	897.9	898.2	0.3
F	451.20	780	13,620	2.1	898.8	898.8	899.1	0.3
G	451.35	755	11,860	2.4	899.0	899.0	899.3	0.3
H	452.32	1000	14,910	1.9	899.9	899.9	900.2	0.3
I	453.63	2710	20,100	1.4	900.5	900.5	900.8	0.3
J	455.18	1020	13,480	2.2	900.9	900.9	901.2	0.3
K	456.13	1140	16,471	1.8	901.2	901.2	901.5	0.3

[1]MILES ABOVE MOUTH
[2]THIS WIDTH EXTENDS BEYOND STATE BOUNDARY

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TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MOORHEAD, MN
(CLAY CO.)

FLOODWAY DATA

RED RIVER OF THE NORTH

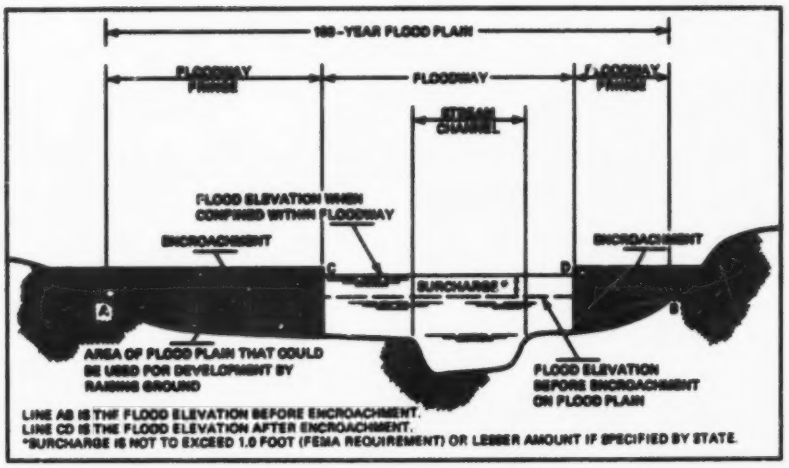
100-YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT.
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT.
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

FIGURE 2 - Floodway Schematic

5.0 INSURANCE APPLICATION

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by detailed methods. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, areas of 100-year flooding where average depths are less than 1 foot, areas of 100-year flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The Flood Insurance Rate Map is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 100-year floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

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For floodplain management applications, the map shows by tints, screens, and symbols the 100- and 500-year floodplains, the floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

7.0 OTHER STUDIES

Due to a more recent hydraulic analysis, the Flood Insurance Study for the City of Moorhead is not in agreement with the Flood Insurance Study for the Unincorporated Areas of Clay County, Minnesota (Reference 12).

A Flood Insurance Study is in progress for the City of Fargo, North Dakota (Reference 13), and is in agreement with this study.

A Flood Insurance Study has been prepared for the City of Dilworth, Minnesota (Reference 14), and due to more current data, is not in agreement with this study.

Due to its more detailed analysis, this Flood Insurance Study supersedes the previously published Flood Insurance Study for the City of Moorhead, Clay County, Minnesota (Reference 15).

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, FEMA, 300 South Wacker Drive, Chicago, Illinois 60606.

9.0 REFERENCES AND BIBLIOGRAPHY

1. U.S. Department of Commerce, Bureau of the Census, 1980 Census of Population, Number of Inhabitants, Minnesota, Washington, D.C., February 1982.

2. U.S. Geological Survey, Water Resources Data for North Dakota, Bismarck, North Dakota.

3. U.S. Army Corps of Engineers, St. Paul District, Fargo-Moorhead Social/Environmental Inventory, 1981.

4. U.S. Department of Commerce, National Climate Center, Climatological Data, Minnesota Annual Summary, 1980, Volume 80, No. 13, 1980.

5. North Dakota State Water Commission and the Minnesota Department of Natural Resources, Division of Water, Soil and Minerals, Red River of the North Regional Flood Analysis, August 1971.

6. U.S. Army Corps of Engineers, St. Paul District, Fargo-Moorhead Urban Water Resources Study, May 1985.

7. ————, St. Paul District, Flood Plain Management Services Unit, Letter Regarding Red River Hydrology and Coordinated Discharge, May 1, 1979.

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8. U.S. Geological Survey, St. Paul, Minnesota, Letter Regarding Red River Hydrology and Coordinated Discharges (open files), April 13, 1979.

9. U.S. Water Resources Council, Bulletin No. 17, Guidelines for Determining Flood Flow Frequency, March 1976.

10. KBM, Inc., Orthophoto Topographic Mapping, Scale 1:2400, Contour Interval 2 feet: Grand Forks, North Dakota, April 1984.

11. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water-Surface Profiles Generalized Computer Program, Davis, California, November 1976.

12. Federal Emergency Management Agency, Flood Insurance Study, Clay County, Unincorporated Areas, Minnesota, October 1984.

13. ————, Flood Insurance Study, City of Fargo, Cass County, North Dakota, in progress.

14. ————, Flood Insurance Study, City of Dilworth, Clay County, Minnesota, May 1981.

15. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Insurance Study, City of Moorhead, Clay County, Minnesota, November 1979.

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ELEVATION REFERENCE MARKS

REFERENCE MARK	FLOOD INSURANCE RATE MAP PANEL	ELEVATION (FEET NGVD)	DESCRIPTION OF LOCATION
1	0010	904.34	southwest flange bolt on fire hydrant located at intersection of South Rivershore Drive and 40th Avenue South
2	0010	907.72	south flange bolt on fire hydrant located at intersection of South Rivershore Drive and 37th Avenue South
3	0010	905.94	northeast flange bolt on fire hydrant located at intersection of 7th Street South and 35th Avenue South
4	0005	905.64	southeast flange bolt on fire hydrant located at intersection of 5th Street South and 14th Avenue South
5	0005	904.99	south flange bolt on fire hydrant located at intersection of 5th Street South and 7th Avenue South
6	0005	904.98	northwest flange bolt on fire hydrant located at intersection of 6th Street South and Center Avenue
7	0005	904.42	northwest flange bolt on fire hydrant located at intersection of 8th Street North and 2nd Avenue North
8	0005	900.52	southeast flange bolt on fire hydrant located at intersection of 11th Street North and Country Club Parkway

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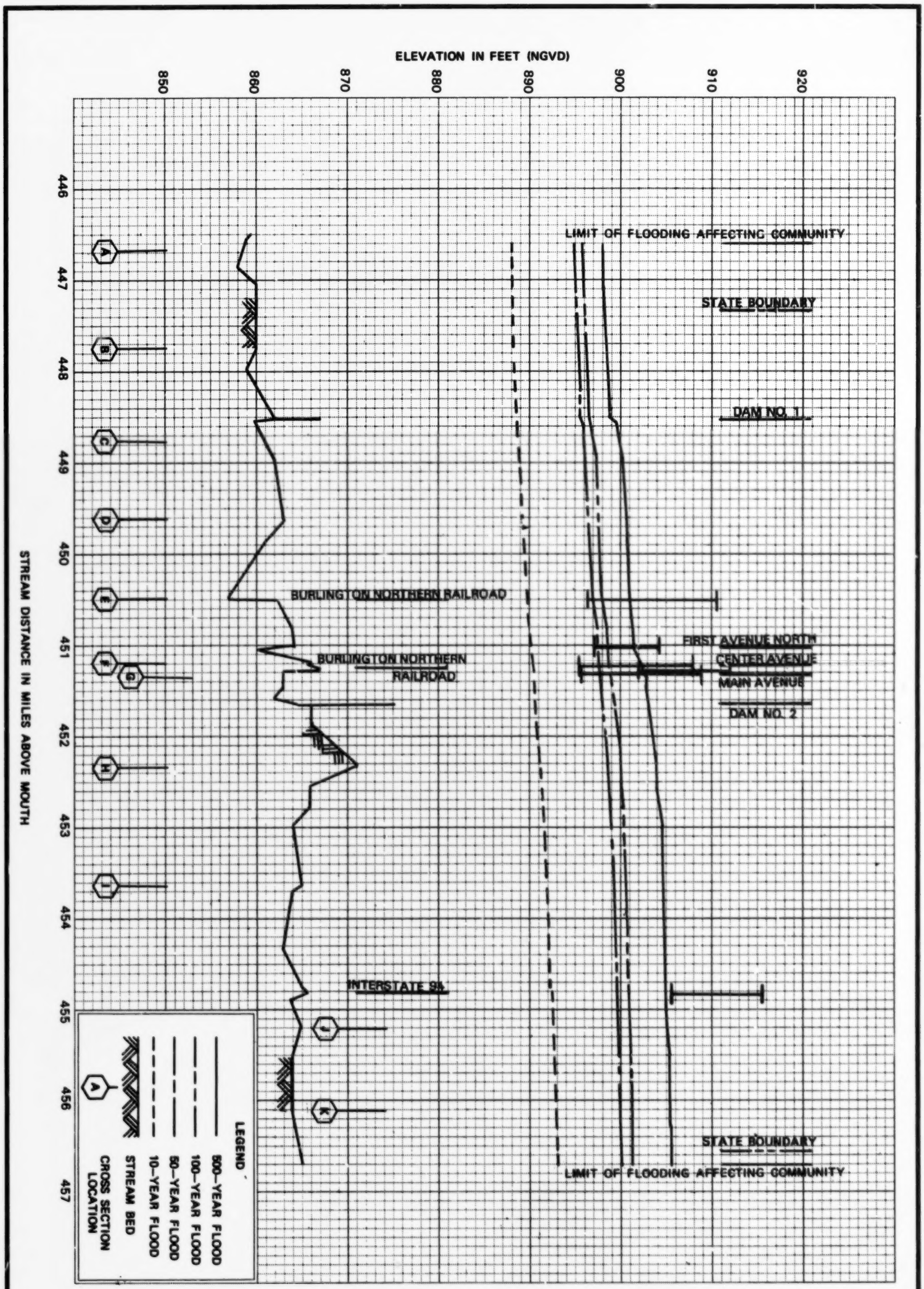

01P	FEDERAL EMERGENCY MANAGEMENT AGENCY CITY OF MOORHEAD, MN (CLAY CO.)	FLOOD PROFILES RED RIVER OF THE NORTH

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